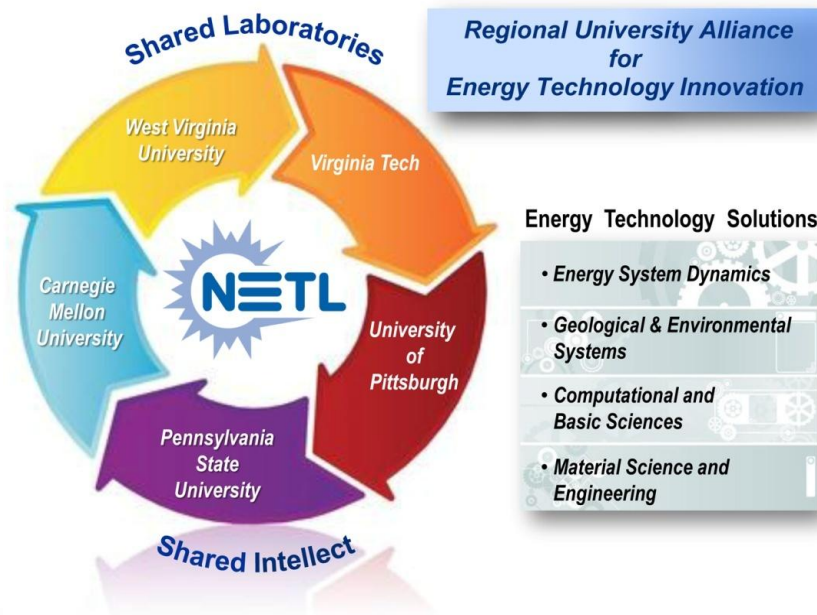




# NATIONAL ENERGY TECHNOLOGY LABORATORY



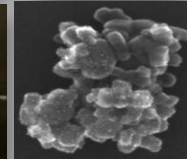
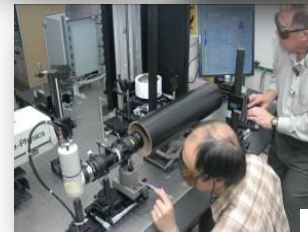
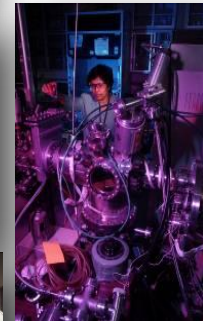
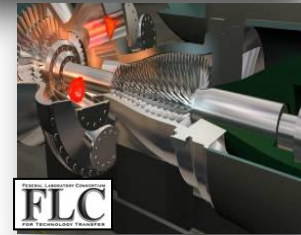
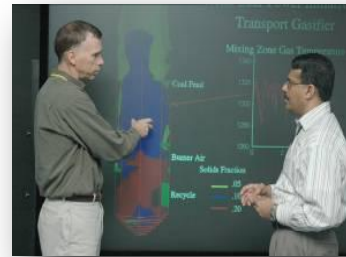
## NETL-RUA : Realizing our Potential

Cynthia A. Powell

Director NETL Office of Research & Development

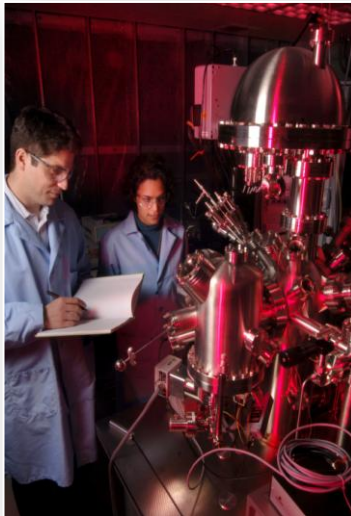
# Motivation for the NETL-RUA

- Build an R&D organization with the combined capability and expertise to be a force in the discovery, development, and deployment of next-generation (energy) technologies.
- Discover and Develop the technology that will launch the next Energy Economy.
- Educate the next generation of energy leaders for the Region and the Nation.



# Philosophy behind the NETL-RUA

Partnership and collaboration to create and enable the right Research Teams to do the right research that effectively meets emerging National need for science and technology.



***Shared  
Resources***

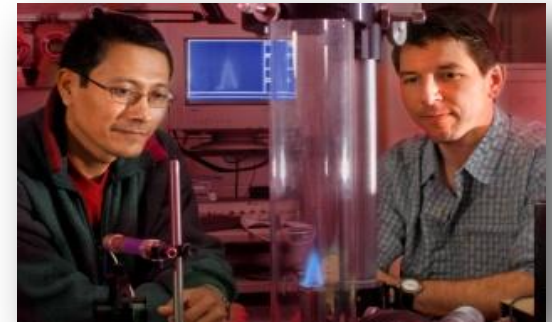
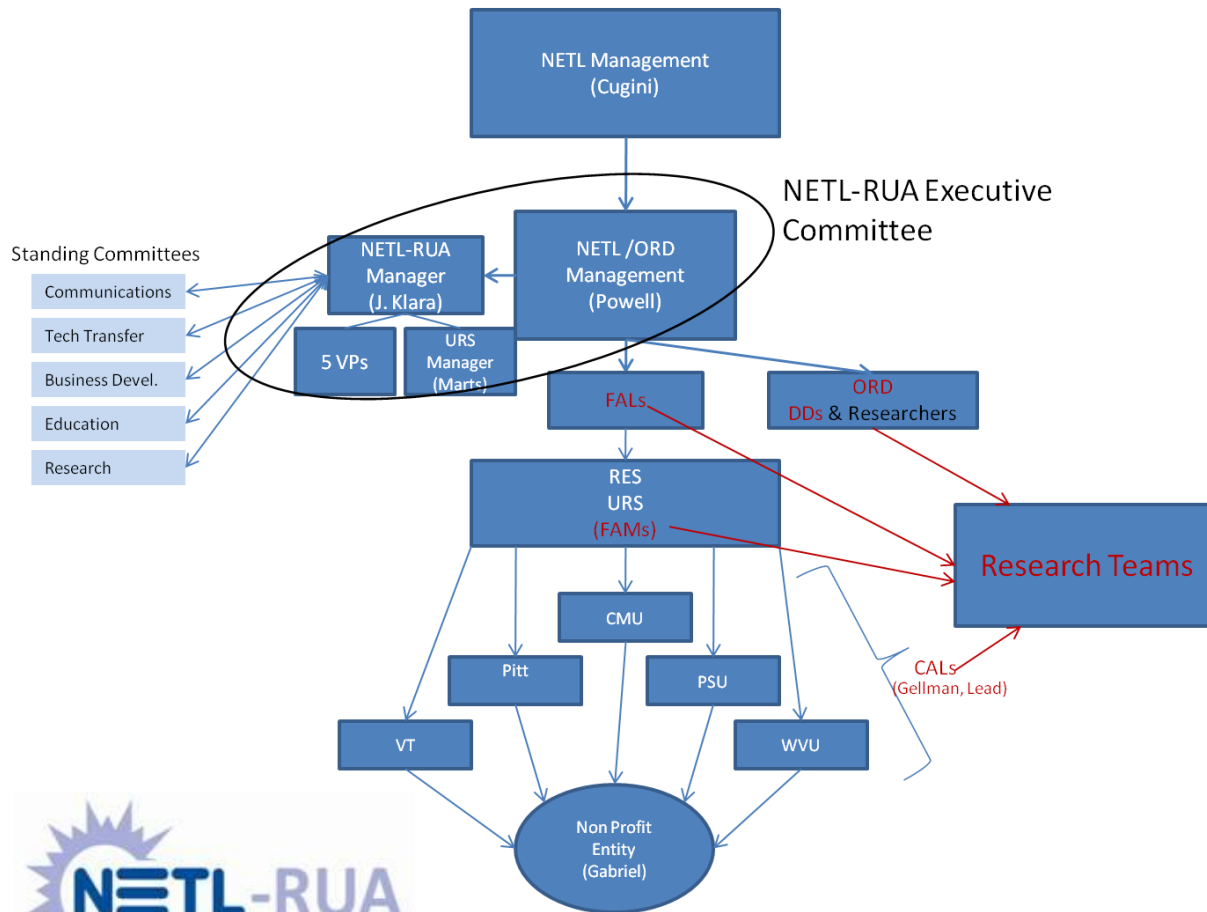


***Shared  
Intellect***



***Technology  
Innovation***

# Creating a Research Alliance



# Vision Statement

*The NETL-RUA will be a recognized global leader in developing the basic sciences and advanced technologies for integrated energy systems, promoting economic development and educating the energy leaders for a sustainable energy future.*



# The NETL-RUA Mission

*To develop deployable energy and environmental technologies to ensure a robust United States energy future through:*

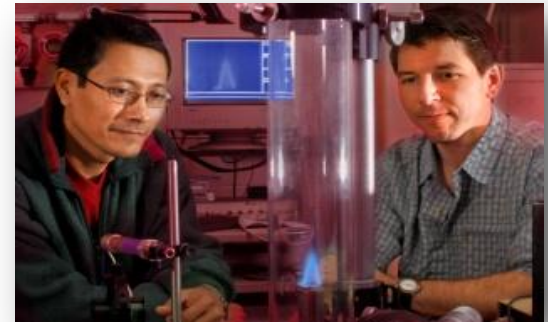
- Developing the basic science and advanced technologies to meet national needs for energy, power, fuels, and chemicals;*
- Accelerating the validation of new concepts by providing access to signature research facilities for a spectrum of energy applications;*
- Driving the commercialization of technologies developed through cooperative programs;*
- Promoting economic development by using advanced technologies as the impetus for spin-off industries; and*
- Educating and preparing the Nation's future energy leaders.*

# Near-Term Strategy for Growth



Expand customer base beyond Fossil Energy by:

- NETL-RUA proposals in response to DOE and other agency solicitations.
- NETL-RUA development of Hubs in areas of DOE interest:
  - Critical Materials and Rare Earths
  - Energy Storage and Batteries
  - Advanced Grid Technologies
- NETL-RUA program development in areas where Alliance expertise and Regional interest converge:
  - Marcellus Shale
  - Materials for Severe Environment Energy Applications



# FY 2011 NETL-RUA Research Portfolio

- 20 Research Teams performing approximately \$42M (planned) in FE research

Advanced Combustion	Capture	CO <sub>2</sub> -Water-Rock
Advanced Gasification	CO <sub>2</sub> Storage	Energy Storage
Advanced Simulation	CO <sub>2</sub> Utilization	Fuel Cells
Multiscale & Multiphase Flow		Membranes
Risk Assessment	QMVA	Seal Integrity
Sensors	Turbines	Fuels
Unconventional Resources	Hydrates	Extreme Drilling

- All Research Teams are composed of two, or more, NETL-RUA organizations. Each Research Team is led by an ORD federal employee.
- As we approach mid-year, all NETL-RUA teams are on schedule, per approved work plans.



# INDICATIONS OF SUCCESS

# Environmental Geochemistry for Fossil Energy

## Determination and Characterization of Process-Critical Geochemical Reactions

### Geochemical Monitoring Techniques

### Contaminant Source, Mobility and Fate

### Microbiological Reactions and Processes

#### NETL:

John Baltrus, Harry Edenborn, Angela Goodman, Djuna Gulliver, George Guthrie, Alexandra Hakala, Richard Hammack, Sheila Hedges, Bret Howard, Barbara Kutcho, Christina Lopano, Bill O'Connor, Kelly Rose, Eilis Rosenbaum, Vyacheslav Romanov, Karl Schroeder, Daniel Soeder, Brian Strazisar

#### ORISE:

Angela Hartsock, Tae Bong Hur, Palwinder Kaur, Andrew Wall

#### URS:

Kristen Carlisle, Jinesh Jain

#### CMU:

David Dzombak, Kelvin Gregory, Athanasios Karamalidis, Gregory Lowry

#### PITT:

Rosemary Capo, Brian Stewart, Radisav Vidic

#### PSU:

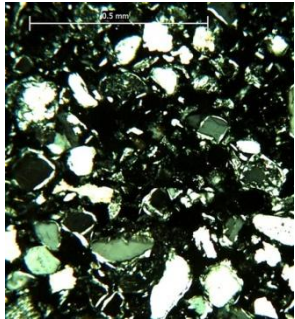
Susan Brantley, William Burgos, Peter Heaney

#### VT:

Robert Bodnar, Donald Rimstidt, Roe-Hoan Yoon

#### WVU:

Shikha Sharma, Dorothy Vesper



# Accomplishments

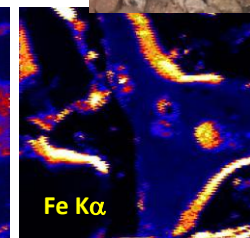
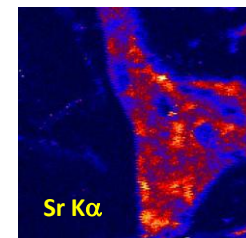
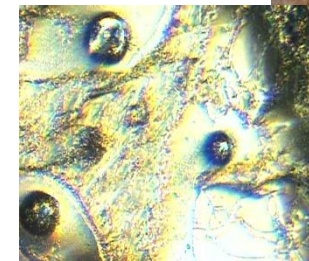
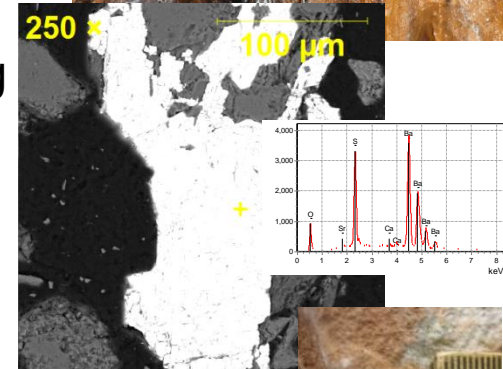
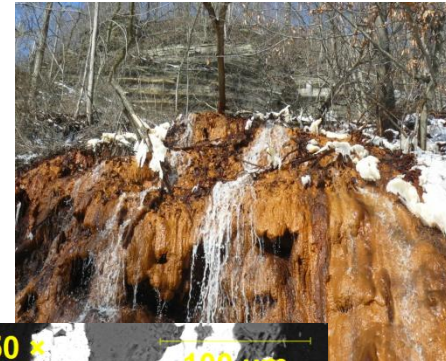
**NETL-RUA Multicollector ICP-MS facility** established and in operation – for preparation and analysis of unique and radiogenic isotopes in natural samples)

**Handling and analysis of produced water samples** – leveraged existing protocols and analytical tools at multiple institutions for comprehensive analysis of shale gas produced water composition

**Multiple-organization field campaigns** to collect samples at CO<sub>2</sub> sequestration, shale gas, and natural analog sites

**10+ presentations and publications in preparation** related to recent biogeochemistry work

**Joint Proposal** submitted to the Deep Carbon Observatory Program



# NETL-Regional University Alliance

## *Process & Dynamic Systems Research*

- Goals & Objectives
  - Collaborate on applied R&D for the design, optimization, operation, and control of advanced energy systems with carbon capture
  - Accelerate deployment of innovative process simulation-based solutions for energy and the environment
- R&D Team
  - NETL: Dr. Zitney, Liese, Jordan
  - CMU: Profs. Biegler, Grossmann, Sahinidis, and Ydstie
  - Pitt: Prof. Mao
  - WVU: Profs. Turton, Bhattacharyya
  - URS: Drs. Ma, Mahapatra



***Stephen E. Zitney, Ph.D.***  
***U.S. DOE/NETL***

Process simulation, CFD, and optimization for plant design; Dynamic simulation and control for plant operations; High-performance computing and virtual simulation



***Lorenz T. Biegler***  
***Bayer Professor, ChE, CMU***

Optimization algorithms and applications, operations research, and numerical methods for process design, analysis, and control.



***Richard Turton***  
***Professor, ChE, WVU***

Design, analysis, and dynamic simulation of advanced energy systems with carbon capture



***Debangsu Bhattacharyya***  
***Res. Assoc. Prof. ChE, WVU***

Dynamic simulation, optimization, control, and sensor placement for advanced energy systems

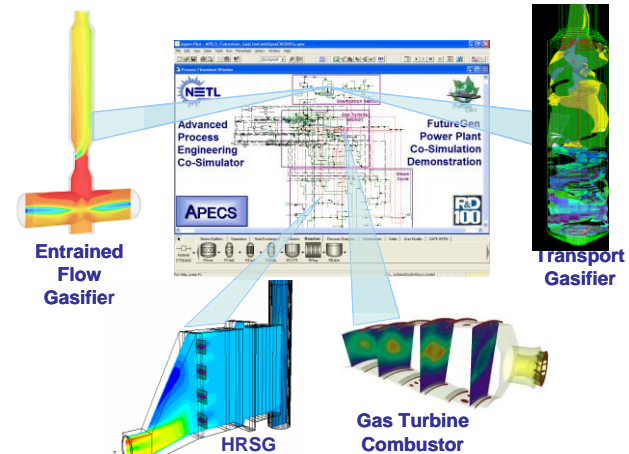
# NETL-RUA: Process & Dynamic Systems Research

## Success Stories

- **Advanced Process Engineering Co-Simulator (APECS)**



- Optimization of plant performance wrt complex thermal and fluid flow
- NETL: Energy Applications, CFD
- CMU: Reduced-Order Models, Optimization
- WVU: Software, Process Simulation
- Tech Transfer: ANSYS
- Industry Partner: ALSTOM Power



**APECS Process/CFD Co-Simulation**

- **Advanced Virtual Energy Simulation Training And Research Center**

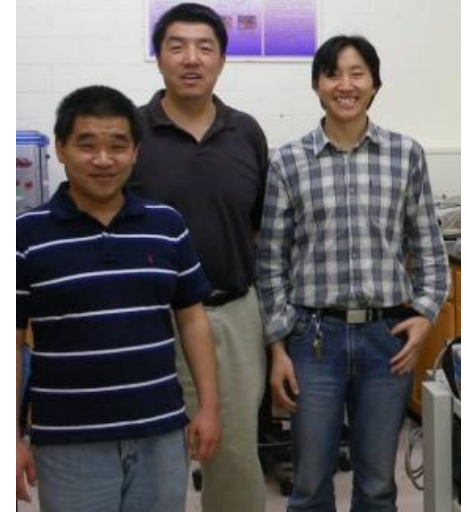
- IGCC Dynamic Simulator (OTS) and 3D Immersive Training System (ITS)
- Deployment: OTS-3/2011, ITS-7/2011
- Locations: NETL-MGN, WVU/NRCCE
- Partners: NETL, WVU, URS, FCS, Invensys
- Industry: AEP, BP Alternative Energy, Doosan, Great River Energy, Southern Co.



# Development of Novel Coatings for SOFC Interconnects – Team and Goals

- **Team Members:**

Xingbo Liu and Junwei Wu (WVU)  
Randy Gemmen and  
Chris Johnson (NETL)



- **Goals: Develop solid oxide fuel cell interconnect coatings meeting critical performance criteria**

- Low Area Specific Resistance
- Block Cr evaporation
- Compatible with other SOFC materials
- Ease of manufacturing and low cost



# Development of Novel Coatings for SOFC Interconnects - Accomplishments

- **Tech Transfer to industry**
  - DoE-STTR Phase I – WVU/Faraday, 2009, \$100K
  - DoE-STTR Phase III Xlerator – WVU/Faraday, 2010-2012, \$1 million
- **Publications / Academic / Awards**
  - 8 journal papers, 50+ citations in last 3 years
  - Subject of a PhD thesis
  - Nominated for 2011 R&D 100 award
  - Patent application filed – WVU/Faraday, 2011
- **Current Status**
  - Working with SOFC stack manufactures (Delphi and Versa Power) to produce interconnect coatings



# PIT-WVU-NETL-URS Collaboration

## *A Successful Partnership*

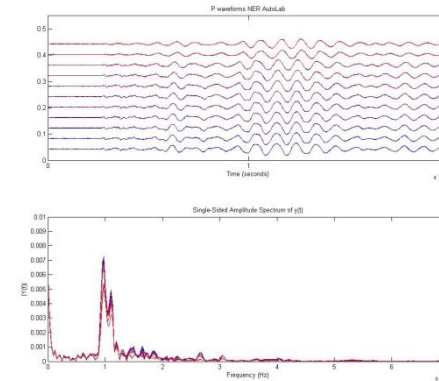
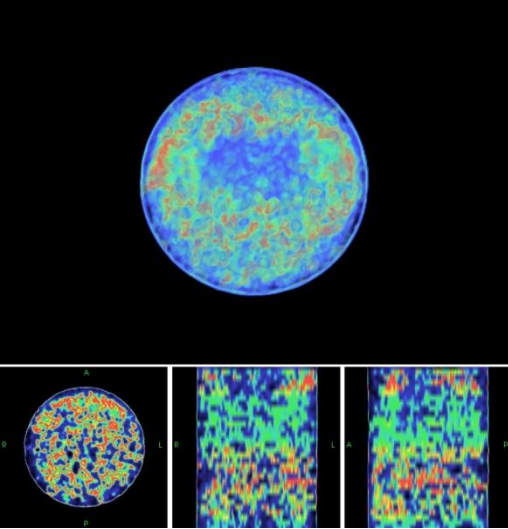
### TEAM – Partners

□ PIT: Bill Harbert, WVU: Hema Siriwardane, NETL: Grant Bromhal, Yee Soong, Dustin McIntire, Robert McLendon, URS: Igor Haljasmaa, Dustin Crandall

❖ **TEAM GOALS:** Various Technical aspects of related to Geothermal  
:Improve image resolution for microseismic imaging and time-lapse active seismic imaging

- Enhance prediction of fluid flow and temperature distributions and stress changes by coupling fracture flow simulations with reservoir flow simulations, and integrating imaging into modeling

Combined competency of team : NETL/URS : modeling, CT scanner, AutoLab Permeability apparatus, Pitt: seismic imaging and WVU : Modeling



## Accomplishments

- **Publications:** 2 Papers in *Int. Journal of Coal Geology*; 1 paper in *Oil & Gas Journal*; 1 Paper in *The Leading Edge*; About 5 conference papers; 4 *journal papers* under preparation.
- **EFRC RESEARCH PROPOSAL** TO BES PROGRAM (18 million dollars among the three groups). Proposal was not funded, but helped define collaborative work. Potential for future funding.
- **Secured \$ 1 million** from an outside agency for a collaborative geothermal research effort
- **New research** on the Application of Tiltmeters for Seismic studies, and with other National Labs.

# **Post-Combustion CO<sub>2</sub> Capture: Layer-by-Layer Nano-Assembled Multilayer Sorbents**

## **Collaboration Goals**

- **Utilize Techniques Discovered in Nano-medicine to Develop a Novel, High Capacity CO<sub>2</sub> Sorbent Based on Layer-by-Layer Assembly**
- **Combine WVU Materials Expertise with NETL CO<sub>2</sub> Capture Expertise to Accelerate Sorbent Innovation**

### **West Virginia University**

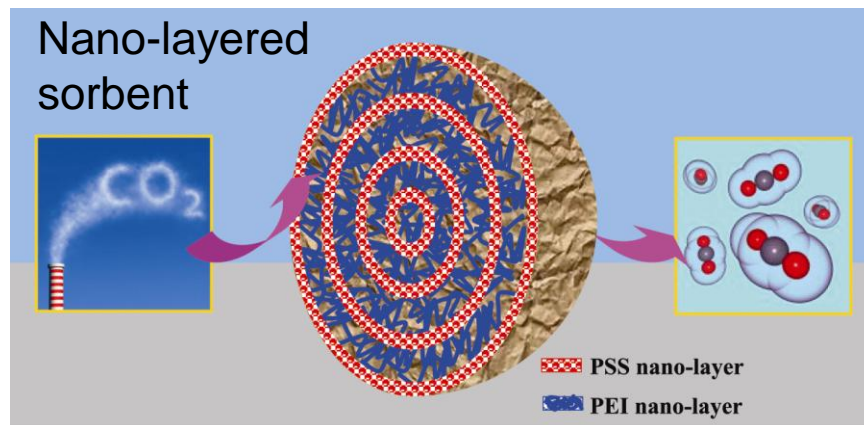
- Bingyun Li, layer-by-layer nano-assembly

### **NETL**

- Yuhau Duan, Modeling
- Daniel Fauth, CO<sub>2</sub> Sorbents
- McMahan Gray, CO<sub>2</sub> Sorbents
- Dave Luebke, Carbon Capture
- Hank Pennline, Carbon Capture
- Geo Richards, Carbon Capture

# Post-Combustion CO<sub>2</sub> Capture: Layer-by-Layer Nano-Assembled Multilayer Sorbents

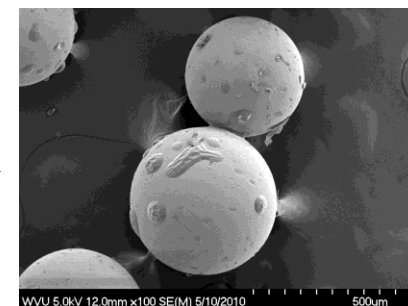
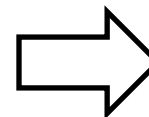
Layer-by-layer  
technique  
established for  
fabrication of amine  
sorbents



Nano-fabrication  
adapted for  
transformation of  
amino acids into  
sorbents at WVU

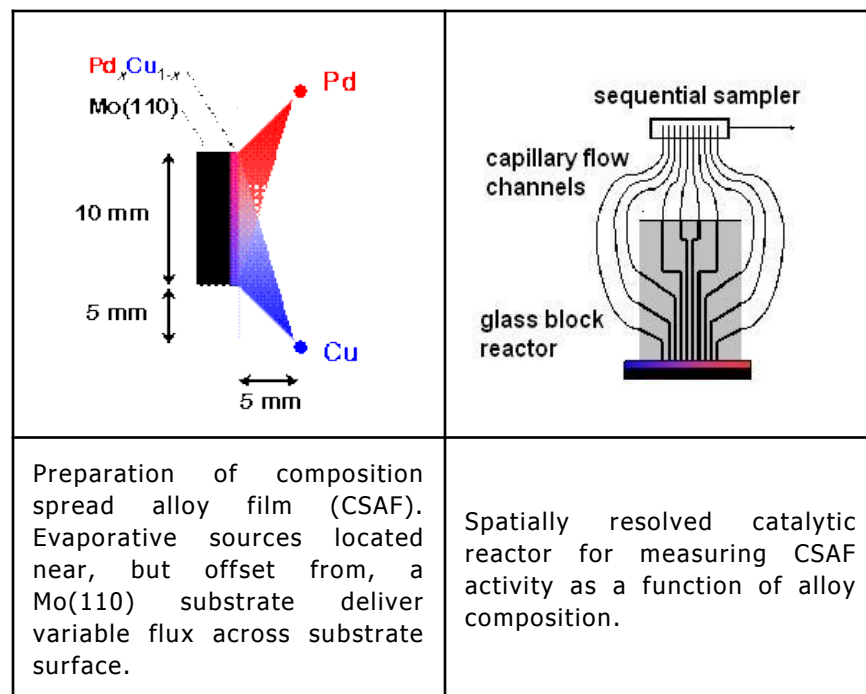


Bench scale testing  
at NETL



## • High Throughput Materials and Catalyst Development

- Composition Spread Alloy Films (CSAFs)—contain every possible composition on a single, compact substrate.
- When coupled with spatially resolved methods for composition and property characterization, a unique ability to rapidly optimize and understand material performance as a function of composition is realized
- 100 channel microreactor array for high throughput studies of catalysis on Composition spread alloy films developed and tested
- 4 Publications (2 in 2008, 1 in 2009, 1 in 2010), 1 Accepted Publication (2010), and 7 Presentations in 2010.
- Professors, Students and laboratory operating at NETL campus.
- EFRC Proposal to BES



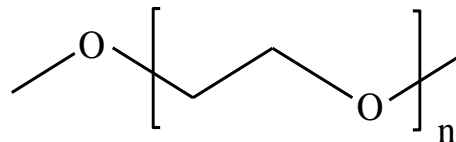
B. Morreale, C. Matranga, B. Howard, D. Alfonso – NETL

A.J. Gellman, J.B. Miller, and C.P. O'Brien - CMU

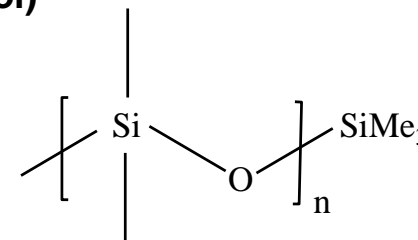
# Pre-Combustion CO<sub>2</sub> Capture: CO<sub>2</sub>-philic Oligomers

## Collaboration Goals

- **Create or identify improved solvents**
  - CO<sub>2</sub> Capacity
  - CO<sub>2</sub>/H<sub>2</sub> Selectivity
  - Hydrophobicity
  - Effective at Higher Temperatures
- **Assess Most Promising Alternative Solvents at the National Carbon Capture Center**



PEGDME  
(Selexol)



PDMS

### University of Pittsburgh

- Bob Enick
- Matthew Miller

### NETL

- David Luebke
- Geo Richards

### NCCC

- Bob Dahlin – SRI
- John Wheeldon – SRI

# Pre-Combustion CO<sub>2</sub> Capture: CO<sub>2</sub>-philic Oligomers

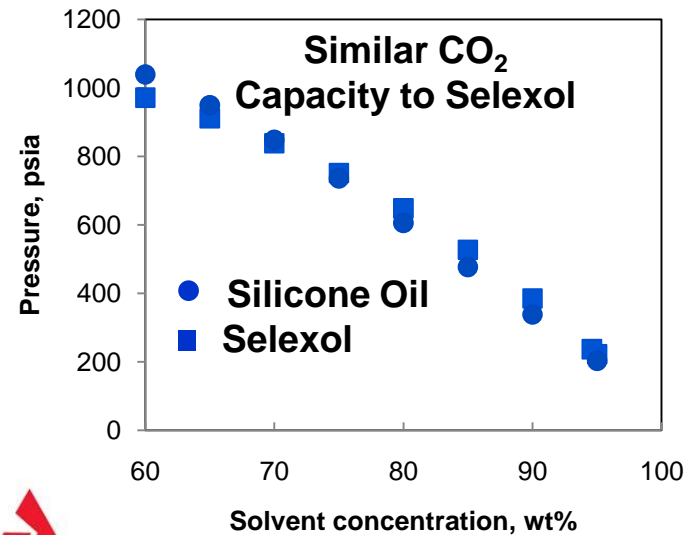


Bench scale solvent screening conducted at Pitt

Silicone oils found which are hydrophobic, inexpensive alternatives to Selexol



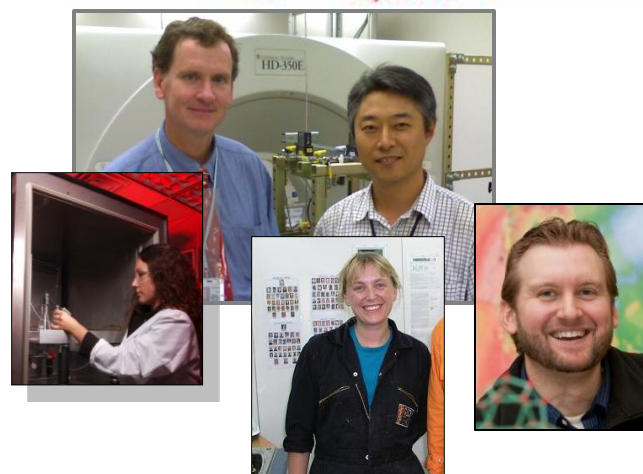
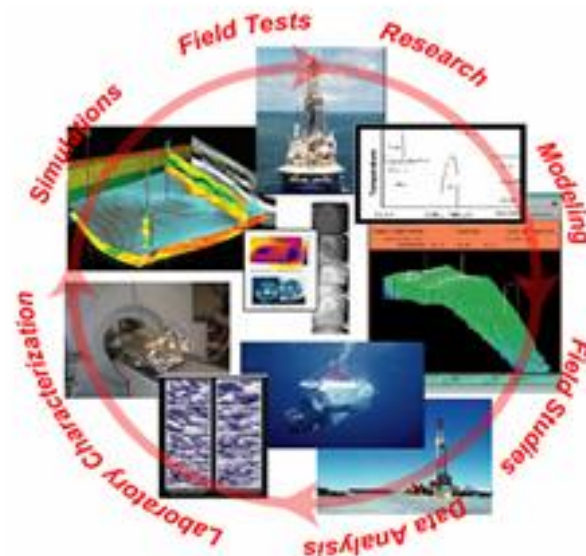
Silicone oils compared to PEGDME (Selexol) as a CO<sub>2</sub> solvent at the Wilsonville Alabama National Carbon Capture Center



# NETL-Regional University Alliance

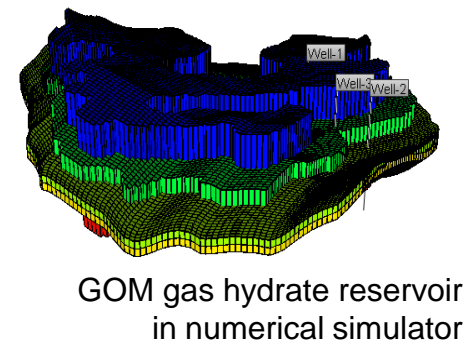
## *Methane Hydrate Research*

- Goals & Objectives
  - Characterize, identify, understand the controls on distribution and occurrence, and relative stability of gas hydrates in the natural environment
  - Assess and mitigate the environmental impacts of hydrate degassing
- R&D Team
  - NETL: Drs. Boswell, Seol, Rose, Warzinski, Rosenbaum
  - Pitt: Prof. Ken Jordon
  - WVU: Prof. Brian Anderson
  - URS: Drs. Myshakin, Liu

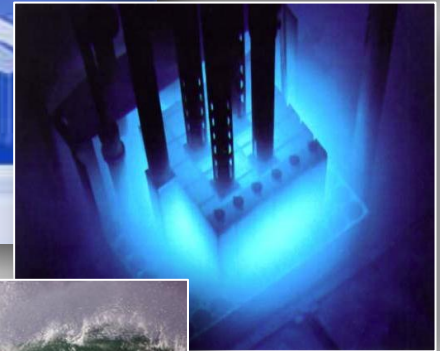


# NETL-RUA: Methane Hydrate Research *Success Stories*

- Success in Chevron/DOE Gulf of Mexico Gas Hydrates Joint Industry Project (NETL-Boswell)
- Leading International Code Comparison Study for natural gas hydrate simulators (NETL-Rose, WVU-Anderson)
- Modified HydrateResSim so it can simulate pure CO<sub>2</sub> hydrate (WVU-Anderson)
- Laboratory synthesized methane hydrate in porous media and x-ray CT visualization (NETL-Seol)
- Numerical Simulation based on field data from the Mount Elbert-01 well, Alaska North Slope (URS-Myshakin)
- Upgrading HydrateResSim to handle multicomponents (URS-Liu)



# ***“Opportunity Knocks...”***



**ARE YOU UP FOR THE  
CHALLENGE?**